

—*Nymphalinae*, *Pierinae*, *Lycænidæ*, and *Hesperidæ*. The only species with marked aposematic colouring and habits was the Lycænid *Alæna amazoula*, and of this only two specimens were offered, both being eaten freely. After fifteen days of this diet the Mantis escaped: she was then as healthy and vigorous as when first captured.

Mantis XI., female, species resembling *Sphodromantis lincola*, Salisbury. Fed solely upon *Acræa caldarena* and *A. axina*, and *Limnas chrysippus*, with long periods of starvation, two of them a month in duration. Seventeen *chrysippus*, six *caldarena*, and three *axina* were eaten without any signs of distaste, while four *axina* were discarded after tasting several times. The Mantis was captured on April 3, 1898, and refused food on September 4, dying on September 8 without signs of ill-health or blindness. Mr. Marshall suggests that the species may be a winter form (possibly of *S. lincola*) specially adapted to eat *Acræas* when other butterflies are scarce.—E. B. P.]

3. CONCLUSIONS FROM EXPERIMENTS ON MANTIDÆ. (E. B. P.)

Certain conclusions stand out very clearly, while others are suggested as probable. These voracious insects did not show any dislike of butterflies outside the *Danainæ* and *Acræinæ*. The undoubtedly aposematic Pierine genus *Mylothris* was freely eaten, and so were the following genera with probable warning colours, movements, and attitudes—*Neptis*, *Alæna*, *Pentila*, and the moth *Egybolis vaillantina*. Even the *Danainæ* were generally eaten without hesitation (II., IV., XI.), and never rejected altogether. In marked contrast was the behaviour of *Mantidæ* towards *Acræinæ*, which were constantly refused, and often eaten only after one or more trials and long intervals of time. When the *Acræas* were eaten freely and without hesitation there is reason for suspecting exceptional hunger. The summary of experiments shows very clearly that "*Pardopsis* appears to be considerably more distasteful. . . than the general run of *Acræas*" (G. A. K. M., October 7, 1897, Malvern). There were also less marked differences in the degree of dislike shown towards other species; thus *axina* was less freely eaten than *caldarena* (XI.); *caldarena* appeared to be eaten more freely than *halali*, *neobule*, *induna*, and *natalica*

(IX.), although the number offered of these latter was insufficient to warrant a certain conclusion; *cahira* was rejected while a considerable proportion of the *encedon* and *serena* were accepted (V.); *horta* evidently possesses a high degree of unpalatability to *Mantidæ* (I., II.).

Mr. Marshall's evidence, by far the most important collected in the case of the *Mantidæ*, is in entire accord with the few observations which had been previously recorded. Thus the late Mr. de Nicéville found that *Acraea violæ* was the only butterfly refused by all the species of *Mantis* with which he experimented in the East ("Butterflies of India, Burmah, and Ceylon," vol. i, pt. ii, p. 318). Colonel J. W. Yerbury informs me that he watched the Mantis *Gongylus gongyloides* hanging from the drooping lavender flowers of a species of *Duranta* at Trinkomali (1890-91), and capturing the butterflies which were attracted by the bloom. The insect hung by its four posterior legs, with head thrown back and predaceous legs held ready for striking. He saw it capture and eat *Delias eucharis* on several occasions, and also *Belenois mesentina* and the Hesperid *Hasora alexis* (Fab.). Colonel C. T. Bingham has also given me a male specimen of the Harpagid Mantis, *Crocobatra urbana* (Fab.), found by him on a Lantana bush actually eating *Delias descombesi* (Boisd.). This observation was made in the North Shan States, Upper Burma, on October 9, 1900. The fact that two species of *Delias* were thus freely eaten compares in an interesting manner with the acceptance of *Mylothris* by the African species of *Mantis*. We may safely conclude that outside the *Acraeinæ*, and doubtfully the *Danaïinæ*, *Mantidæ* devour butterflies very freely, the species with warning colours as well as the others, and that they are far more indiscriminating than the majority of vertebrate insect-eaters. Thus Mr. F. Finn found *Delias eucharis* to be one of the most distasteful of all butterflies to many species of Indian birds ("Journ. Asiat. Soc. Beng.," vol. lxxvii, Pl. ii, No. 4, 1897, p. 667). Mr. Finn also found in East Africa that a moth of the genus *Egybolis* (*E. vaillantina*) was refused by a Chamæleon and a Gecko ("Natural Science," vol i, No. 10, Dec. 1892, p. 747). It is of deep interest to find such marked differences between the preferences of the various groups of insect-eating animals.

In addition to the observations recorded above, Dr.

David Sharp, F.R.S., quotes Mr. F. Muir concerning the food of *Idolum diabolicum* (Sauss.) at Mozambique :—" Its food seemed to consist of flies, *Limnas chrysippus* being rejected, even when hungry, and other butterflies only taken for lack of other food" (Proc. Cambr. Phil. Soc., vol. x, pt. iii, p. 175). Mr. Edward Barlow (Proc. Asiat. Soc. Bengal, Dec. 1894) states that *Hierodula bipapilla* (Serv.), kept in captivity at Calcutta, ate ordinary flies (*Musca* sp.) with avidity, but attacked with great reluctance the common large green blowfly (*Lucilia* sp.), only eating them when they could get nothing else. Two bugs, *Cyclopetia* sp. and *Physomerus* sp., offered when the Mantis was very hungry were never eaten, although often killed. After tasting the former, the Mantis wiped its mouth against its right fore-leg several times. This last observation is the only record I have found of Hemiptera offered as food to *Mantidæ*.

The question arises as to whether the preferences exhibited by *Mantidæ* in captivity are the same as those which exist in the wild state. A Mantis is probably less affected in this respect by confinement than a vertebrate animal; but the same general criticism will probably hold in both cases—that while the rejection of an insect by a not over-fed insectivorous animal in captivity is evidence of unpalatability or dislike, its acceptance is not sufficient evidence of appreciation or that it constitutes an element of the normal diet. An insect may be eaten readily in captivity which would be rejected or only eaten under the stress of hunger in the wild state; for it is generally quite impossible to supply an animal under artificial conditions with the variety and often the quantity of insects which it would catch for itself. In this respect a large Mantis can be kept in a more normal condition than an insectivorous vertebrate, because of the much larger amount of food required by the latter; although the young Mantis would offer great difficulties to the breeder, because of the vast numbers of very minute insects which it would require. But Mr. Marshall's experiments yielded plenty of evidence of the positive refusal and acceptance, as it were under protest, of *Acræinæ*, so that there can be no doubt of their distastefulness to this class of enemy, although acceptance might under the circumstances have not been convincing proof of their palatability. It is however in every way satisfactory to obtain evidence

from the behaviour of *Mantidæ* in the wild state, and such as we do possess entirely confirms the conclusions to be drawn from Mr. Marshall's experiments. In the first place we have the following observation of his own, made in the Karkloof, Natal, in February 1897 :—

“Saw a Mantis catch a male *horta* on a flower in the veldt. It began eating at the base of the abdomen, which it consumed entirely, and then started on the thorax, of which it only ate a very little, and then threw it away.”

This observation corresponds almost precisely with many made upon the captive insects. Mr. Roland Trimen also says that he never found the wings of *Danaïs* or *Acræa* among the fragments of butterflies which sprinkle the ground below the feeding-place of a large Mantis, although he is careful to add that he could not be sure that these butterflies visited the exudations of Acacia sap, round which the predaceous insects secure a plentiful supply of food (Linn. Soc. Trans., vol. xxvi, 1870, p. 500). It has already been pointed out that Colonel Yerbury's and Colonel Bingham's observations upon *Mantidæ* in the wild state are entirely confirmatory of Mr. Marshall's observations of them in captivity, as regards the food which appears to be freely provided by certain Pierine genera refused or disliked by other insect-eating animals.

Another question of deep interest raised by Mr. Marshall's experiments on *Mantidæ* is the inquiry how far the species which they reject or eat only sparingly is unwholesome or even poisonous to them. There is strong *à priori* probability for the view that the preferential appetite of such a form as a Mantis is merely the strong instinctive tendency to eat the food which best suits its organization and reject that which suits it least. We should expect therefore that such marked disinclination to eat *Acræas* as we observe in *Mantidæ* indicates, not distaste or unpalatability in an anthropomorphic sense, but merely that *Acræas* are unwholesome to *Mantidæ*. The evidence requires to be sifted in detail.

In Experiment III. the signs of weakness seem to be a too-excessive result of the single *Acræa*, and portion of another, which were eaten. At the same time generic and specific differences are almost certainly of great importance, and it must be remembered that III., IV., and VII. belonged to probably the same species, and all exhibited weakness after an *Acræa* diet, resulting in the death of

IV., the deformity of VII., while III. was released. Experiments V. and VIII. were also upon the same species of Mantis. The first, a male, became weak and probably blind after eating a few *Acraeas*; the second, a female, remained apparently healthy after an exclusively *Acraeine* diet for fourteen days. It is very unfortunate that this latter experiment could not be continued. It is, however, clear that in the case of this species and sex a purely *Acraeine* diet for fourteen days is not necessarily unwholesome. Experiments IX., X., and XI. were upon species which were the same, or nearly the same, and all females. The first died after an *Acraea* diet for twenty days, the second was perfectly healthy after a mixed butterfly diet without *Acraeine* and *Danaine* for fifteen days, while the third lived healthily from April 3 to September 8 upon *Acraeas* and *Limnas chrysippus*. The latter seems to be an insuperable difficulty, but it must be remembered (1) that *chrysippus* was given in especially large numbers, and there is no evidence that *Danaine* are much rejected by *Mantidæ*, (2) that the Mantis may have recovered from the effect of the *Acraeas* during the long fasts, (3) that the *Acraea* chiefly made use of, *A. caldarena*, may be less unwholesome than the majority of the group.

More experiments are greatly wanted, but Mr. Marshall's observations render it highly probable that *Acraeas* are unwholesome to *Mantidæ*. The definiteness of the symptoms exhibited, and especially the effect upon the eye, constitute not unimportant evidence in support of this conclusion. The appearance of an opaque blotch in the left eye of three of the Mantises (V., VII., IX.) suggests further experiments in order to test whether we have to do with mere coincidence or a phenomenon of deeper significance.

Mr. Marshall's conclusions from his experiments were written upon the results obtained with spiders as well as Mantises, and will be found at the end of the section upon the former (p. 322).

4. EXPERIMENTS ON SPIDERS IN THE KARKLOOF.

(G. A. K. M.) Natal, February 1897.

[The Rev. O. Pickard-Cambridge, F.R.S., informs me that the species made use of was the common and widely-distributed Epeirid *Nephilengys malabarensis*, Walck.—E. B. P.]